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ABSTRACT

Implications of biophysicist Herman Epstein's research on brain growth periodization, which develop a neurobiological consideration of learning issues for middle school curricula, have created controversy among educators and stimulus for further research. This presentation (1) summarizes the writer's interpretations of these data and implications for middle level education and considers more recent data reinforcing these findings, (2) raises questions requiring further investigation, and (3) responds to criticism of brain growth periodization data and their suggestions for middle level education. Describing special mind and brain growth periods based on study of brain, skull, and mental development, Epstein has identified both growth spurts and slower brain growth intervals. He posits that this relationship between brain and intelligence development might explain the developmental learning stages established by Piaget. The areas of brain hemispheric specialization and neural plasticity offer additional reasons to respond to this growing database. Longitudinal research by curriculum planners and neuroscientists must be undertaken to discover appropriate facilitating activities for precocity and identification of other stage task activities. Rather than trying "harder and earlier" to get children to master subject matter and cognitive skills, the central research issue remains to match the learner's readiness, cognitive level, and difficulty of the learning challenge. Six pages of references conclude the report. (CJH)

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Presentation to the New England School Development Council Middle School Workshop, Westboro, MA., May 16, 1986

IMPROVING INSTRUCTION IN MIDDLE LEVEL SCHOOLS:

IMPLICATIONS OF NEUROLOGICAL DATA FOR CURRICULUM DEVELOPMENT

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The 1977 issue of TRANSESCENCE (Vol. V) introduced biophysicist Herman Epstein's notions about the implications of his research on brain growth periodization for middle school curricula to middle level educators. This information has drawn the interest of educators during the intervening years. Professor Epstein's work led to the development of cognitive level matching approaches best known in the Shoreham-Wading River, New York School District. As new ideas do, the brain growth periodization issue has raised controversy. Criticisms of new developments are in order to identify accuracy in that area of investigation and to move its "state-of-the-art" forward. However, to be helpful toward this objective, the accuracy and context of the criticisms themselves also require examination.

This presentation: (1) summarizes this writer's interpretation of these data and their implications for middle level education and considers more recent data reinforcing these findings; (2) raises questions requiring further investigation; and, (3) responds to particular criticisms made of the brain growth periodization data and their suggestions for middle level education.

The Living, Growing Brain and Mind

Contemporary information explosions in both psychology and neurology are providing bases for rethinking all areas of human behavior. These data offer fascinating possibilities for considering new dimensions about how transescents can and do think and learn. The ways in which people learn require our consideration of the different ways in which they demonstrate their individual ways of learning and processing information. Guilford's concerns (1967) about the structures of intellect set the need to pursue this area as a challenge to scholars and researchers to examine how human learning abilities

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progress as children grow and develop. There is a major need to screen neurological findings about how the brain actually functions against current developments about learning from the area of psychology. This would develop a neuropsychology of learning (Hynd & Obrzut, Reynolds, 1981, 1982) and provide an on-going basis to syncretize of these findings as they emerge.

This writer contended (1982) there are important implications in brain growth periodization information for rethinking curriculum design of school experiences for children. Educators have more or less assumed that there is a constant continuum in the growth of the mind and thinking capacities of children. Until the past two decades, there has been relatively little consideration of the implications of stage-wise growth of thinking levels and of the brain during childhood and adolescence. The area of learning psychology was first to develop data leading to such considerations. Neurological discoveries during the past decade raise the same questions to all educators and to middle level educators in particular. Before considering any neurological issues, educators should consider appropriate learning psychology issues. Our professional preparation allows us to deal with that information. These learning psychology concerns developed prior to and apart from the neurological studies. Also, they were separate forerunners of any major considerations of how neurology might influence the development and organization of teaching-learning activities. The former also offers important suggestions for transescent educational strategies. The writer will attempt to acquaint the reader with these data bases as he sees they have implications for middle level education.

Piaget's Stages of Learning

Psychologist Jean Piaget posited that learning stages appear as youngsters grow chronologically. This was based upon years of study of young children at the Rousseau Institute in Geneva Switzerland. Dr. Piaget (1969) identified that most children exhibit new and higher level intellectual skills during four, relatively common age-linked periods. He described the first of these stages as the sensorimotor period and identified that children learn primarily through their senses from birth through age one-and-a-half to two years of age. The second Piagetian stage, known as concrete preoperational learning stage, occurs for most children between age 2 and 7 years. During this stage, children

largely develop their capacity for manipulating symbols that represent their environment.

The third Piagetian learning stage occurs for most children between 7 and 11 years of age. It marks the stage which is transitional to task of growth and development which bring children to their middle level educational years. During age 9 to 11 years, many children are approaching and achieving their transition from early childhood to the beginning of adolescence. In THE MIDDLE SCHOOL, Donald Eichhorn defined the epoch youngsters experience during their middle level school years as "transescence." His definition deals with the reality of the tasks which youngsters need to master during the metamorphosis and transition in that period.

> "The stage of development which begins prior to the onset of puberty and extends through the early stages of adolescence. Since puberty does not occur or all precisely at the same chronological age in human development, the transescent designation is based upon the many physical, social, emotional, and intellectual changes that appear prior to the puberty cycle to the time when the body gains a practical degree of stabilization over these complex pubescent changes." (p. 3)

The term has subsequently been broadly utilized by the National Middle School Association (Lounsbury). The physical, social and emotional demands upon children during this metamorphosis are extremely stressful. The fact that some youngsters are well into their pubescent metamorphosis by age 11, while others have not begun it, creates adjustment problems in their personal transescent experience. This concern can also distract them from dealing specifically with the changes in intellectual capacities experienced during the consolidation of their concrete operational processing skills. This marks the first time in their life in which major differences in body size, shape and sexuality impact upon individual and peer relationships. Concerns over one's own precocious, average, or delayed beginning of the pubescent transformation brings concerns to concrete operational thinking children which disrupt earlier commonality of development formerly experienced with the majority of their agemates. These differences will continue to intensify during the next (formal operational, age 11-15 years) developmental period. The years of concrete operational development must also cope with school environmental changes as students move from self-contained, elementary school classrooms to junior high and middle school buildings. In the latter, they will begin to deal with as many as 6 individual teachers during the school day. They also are now the youngest and often among the smaller students in the school, whereas, they were the oldest and the student leaders in the elementary school. The

characteristics of the maturing child's intellectual development during her/his "concrete operational learning stage" are shown in Figure 1.

Figure 1: Piaget's Concrete Operational Learning Stage

The Maturing Child

can perform elementary logical operations on concrete objects as s/he liberates her/himself from largely perceptual judgments.
performs operations such as serial ordering, classification, numbering, space and time, and associated operations such as associativity, transitivity, identity and negation.
begins to be troubled by inconsistencies in thought and action.
becomes logical and develops reversible thinking.
develops conservation skills. (e.g., the majority can do length and quantity around age 7, weight around age 9 and volume around age 11)
becomes less egocentric in representing objects in her/his social relationships.
can deal somewhat with complex word problems.

During the final two years of this stage, educators need to organize learning experiences which initiate and mature concrete operational level skills while assisting students as they deal with the beginnings of the physical, social and emotional developmental variance previously described. This poses a range of complicating factors as readiness for development of these skills s assessed and learning activities initiated. Early physical development may or may not be linked with earlier readiness either for creativity development or readiness to initiate concrete operational tasks during this period. Problems of self-concept and esteem caused by individual child differences in pubescent development from her/his peers may interfere with the ability to concentrate on cognitive activities even though that child does have the necessary readiness. Teachers dealing with this age group must maintain flexibility in their expectations about consistency of student reactions. Their individual behavior and mood will fluctuate greatly because of episodes over which there is virtually no control. The use of appropriate approaches by adults in planning learning activities for his age group will be an important in developing effective, concrete operational learning activities. This can assist in dealing with readiness issues which become increasingly more difficult to identify during this ageframe. The difficulties of beginning transescent tasks which emerge during the age 10 and 11 years of this learning stage should not be underestimated.

The final Piagetian stage occurs for most youngsters between 11 and 15 years of age and coincides with the transescent period of development for most. The social and emotional emancipation begun for

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most maturing children during the concrete operational timeframe continues. The age 11 to 15 ageframe extends the complications of pubescent adjustment, development of sexuality, and sex role identification. This is accompanied by heavy increases in peer pressure and expectations and further complicated by the fact that individual pubescent transformation differs not only between, but within the sexes. Females generally experience this transformation as much as 10 to 18 months earlier than males. There also may be a variance as great as 3 years between two members of the same sex who demonstrate the same level of pubescent development, one of whom is very precocious and the other, who is delaying significantly in physical, pubescent arrival. These physiological phenomena create major social and emotional concerns during the ageframe in which the transition to begin formal operations usually begins. This often creates serious distractions which hinder young transescents from attending fully to the intellectual tasks they face in initiating formal operational skills and meeting the tasks of this learning stage. The characteristics of the maturing adolescent's intellectual development during her/his "formal operational" learning stage are shown in Figure 2.

Figure 2: Piaget's Formal Operational Learning Stage

The Adolescent

approaches and gradually begins hypothetical-deductively as reasoning becomes more abstract.
begins to perform operations of formal logic.
can use mathematical operations associated with groups and lattices in complex combinations.
can do reasoning with proportions and ratios.
can begin to think reflectively and accept assumptions which are contrary to facts.
can perform controlled experimentation.
becomes concerned about reality and introduces idealized schemes to bring reality in line with her/his own thinking.
becomes relatively freed from dependence on concrete reality.
can subordinate the content of a problem to the form of relations within it and is impressed by the form of an argument over its content.
can reverse directions between reality and possibility and check the viability of the latter by experimentation.
can reason conjunctively, disjunctively, by negation or implication.

During the formal operational learning stage transescents develop intellectual characteristics which shall mature into her/his adult information cognition skills. The great percentage of humans achieve their full range of information processing skills and cognitive capacities which will influence their creative thinking abilities during this age frame. While Arlin (1975) posits there may be an additional stage of problem defining skills for some, most later adolescents and adults will only refine

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and mature their existing capacities. Few people appear to develop new or higher level skills from what they achieve during the formal operational learning stage.

Middle level educational research needs to identify the degree to which intervention strategies could either develop or further mature one's intellectual skills or tendencies during this last Piagetian cognitive stage. The investigation of latency issues should assist in identifying why some individuals delay in developing and manifesting higher intellectual abilities until well into their adult years.

Recent Psychological Findings and Transescent Readiness Concerns

David Elkind (1980) observes that it is extremely difficult for adults to really understand children's thinking levels when adults can function at cognitive levels above those of the child. He describes this ability of adults to process information using their personal, full range of thinking skills as "automatization." It is, he states, almost impossible for adults to understand how a child processes information when the adult is automatically functioning above the child's maximum cognitive level. Professor Elkind describes the state of a child who has not yet reached the adult's thinking levels as "the intellectual unconscious." He notes that "Getting at the intellectual unconscious, however, presents a very special problem. Once a person becomes truly skilled in a particular action, there is no way to get back to the intellectual unconscious." (p. 19) Piaget identified (1958, 1967) that a child must construct the environment in which s/he develops new skills and then use them to learn new information.

For example, let us assume that a particular 7th grade learner has not yet progressed beyond the concrete operational thinking level. When thinking at that level the student, however, is using her/his highest "intellectual gear." Let us also assume that this transescent's teacher is a formal operational thinker who has developed skills in cognitive levels matching. Thus means this teacher can communicate with that student at the latter's concrete operational levels. However, s/he is "shifting down" from her/his "high (formal) thinking gear" to concrete operations while this concrete operational student is using her/his "highest thinking gear." It is important to consider the following about "automatization" in this idea of constructivism.

That student needs to construct the environment which s/he needs to function at concrete

operational thinking levels. However, teacher who must "down shift" to match the concrete operational level will "automatically" think about formal operational applications of those concrete level skills in dealing with the concrete operational student. Also, the student cannot and does perceive these formal relationships as long as concrete operations remains her/his highest achieved thinking level. Thus this teacher can not fully recall how one thinks when the concrete operational level is the limit of one's thinking abilities. The implications of Piaget's ideas on constructivism will be discussed further in a later section.

To deal with how children can and do think at a particular age, adults must likewise identify the components of the stages and levels of learning which the child has achieved. Without this knowledge, the teacher may plan new instruction which is either beyond or below the child's actual readiness and create problems as that child attempts to understand things which are beyond her/his readiness at that time. Learning challenges may inappropriately be ones either over or underchallenge the youngster in terms of the learner's developmental readiness and ability to learn. This can cause problems. In the case of overchallenge, if the transescent attempts to learn and understand content and skills which overchallenge and are beyond her/his readiness at that point, the effectiveness of learning may be complicated as understanding is clouded by frustration, confusion, and strict rote memorization. In the case of underchallenge, the transescent may not fully challenge and develop her/his abilities at that time. As a result, the student may become bored and develop less positive attitudes about learning than if s/he were being challenged to fully use those abilities. The implications of this notion for planning middle level school learning activities are discussed later in the section dealing with cognitive levels matching.

Joseph Adelson's reflection on James' 1890 observation that "to identify the moment of the instinctive readiness for the subject is, then, the first duty of educators" was that James was "discussing that which we now call cognitive readiness - the level of intellectual growth that allows the student to grasp the knowledge offered by the teacher" (Adelson, p. 157). Piaget's personal interests were in working with younger children. Consequently, his data provide far less information about students of age 11 years and older (the formal operational learning stage) and offers less help to those who work with learners at that learning stage.

Professor Adelson is concerned with identifying how soon young adolescents (age 11-14 years) actually develop full formal reasoning skills. Data from his work identify that the 12 year old normally "does not have the conceptual framework by which to organize and order the information that the educator provides." On the basis of his investigations with both younger and older adolescents, professor Adelson concluded that "the major difference between younger and older adolescents was the capacity of the latter to think abstractly when the occasion demanded it" (p.157). Figure 3 presents four of professor Adelson's tables which display these data.

Figure 3: Differences in Abstraction Between Young and Older Adolescents

Table 1. Percent Demonstrating Different Levels of Abstraction in the Conceptualization of Government (N = 326)

By Age	11	13	15	18
Concrete	57	27	07	00
Low Level Abstraction	28	64	51	16
High Level Abstraction	00	07	42	71
Don't Know or Not Ascertained	15	05	00	13

Table 2. Percent Mentioning Community Survival in Describing Purpose of Mandatory Vaccination (N = 434)

By Age	12	14	16	18
Survival of Community	07	14	23	45

Table 3 Percent Offering Different Opinions on the Purpose of Laws (N = 433)

By Age	12	14	16	18
Restriction	37	35	29	19
Setting Standards	16	22	34	34
Sense of Community	02	09	14	18
Other	45	34	23	19

Table 4 Percent Offering Different Opinions on the Purpose of Government (N= 336)

By Age	11	13	15	18
Restriction	73	68	44	20
Restriction and Benefit	12	18	33	38
Benefit	07	08	20	41
Other	08	05	03	01

[Tables from Adelson, pp. 157-159]

Professor Adelson found that young adolescents (transescents) do not move as rapidly into

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formal operations as Piaget's original data might cause one to expect. Recall the comments made earlier when introducing the section on the Piagetian learning stages. They were to the effect that Piaget's primary interests were in young children. The majority of his work was done with children of ten years of age and younger. His detailed investigations of children's intellectual skill development during the first three learning stage ageframes developed accurate estimates of the ageframes at which most children could be expected to manifest progressively higher intellectual abilities during each learning stage ageframe.

Piaget did correctly identify that children demonstrate the capacity to develop formal operational thinking in the 11-15 years ageframe. However, because of his lesser interest in this older age group, he did not study them in the detail he did with younger children. This lack of such detailed study also meant there was not a similar establishment of the pace at which progression into formal operational skills could be expected during this final learning stage ageframe. The individual works of professors Elkind and Adelson helps establish that most transescents do not move rapidly into formal operations at the beginning of the fourth Piagetian (formal operational) learning stage. It also appears that consolidation of concrete skills initiated in the prior concrete operational stage continues and establishes the basis for gradual development of beginning formal operational capabilities by transescents. The data presented in Figure 3 offer educators who work with the age 11-14 years ageframe compelling reasons to rethink notions about how rapidly transescents can be expected to develop formal thinking skills.

Professor Adelson's work further suggests major frontier issues as middle level education attempts to deal transescent intellectual development during the formal operational ageframe. Arlin (1984a) has developed a test which measures the thinking level abilities of youngsters. The test identifies whether the transescent has achieved onset or mature concrete or onset or mature formal operational abilities at that time. Use of this test in further pursuing professor Adelson's findings would help to define and establish the relationship between learning stage readiness curriculum skills and content which can be effectively presented during the ageframe in which most humans develop their abstract learning skills.

The learning psychology areas discussed here provide an important data base for investigating the

degree to which transescents can and do initiate and mature formal operations during the typical middle level educational years. Careful consideration of the ways in which students mature concrete operational thinking and initiate formal operations during Piaget's last intellectual development stage is essential to identify the kinds of intellectual challenges which realistically can be successful in dealing with transescents. Studies of achievement during the age 10 to 14 age range historically show the following. Achievement during the age 10-12 year interval (which includes most 5th and 6th grade youngsters) is very high. However, it is also clear that growth in achievement during the following 12 to 14 years age interval (which includes most 7th and 8th grade youngsters) is quite low among transescents in the United States.

To what degree do school programs have a similar expectation for growth in learning of higher level skills during both intervals? Examination of school curricula in the middle grades shows that teaching and learning of new facts and information during both intervals is attached to the expectation that transescents do progress continually in their thinking capacities. That investigation reveals three consistent conditions. First, curriculum challenges during the age 12-14 years interval are attached to expectations for developing maturing formal intellectual skills. Second, the subject matter taught during that time requires those skills to fully understand and process the facts and information taught at this time.

Brain Growth Periodization

Herman Epstein related information about the physiological growth of the brain to previously known information about the mind's capacity to grow in its ability to process information at progressively more difficult stages. His data and notions about brain growth periodization brought such information to the attention of educators. Developed from professor Epstein's biophysicist perspective, these data deal with developing a neurobiological consideration of learning issues. Called phrenoblysis, this was described by professor Epstein as special mind and brain growth periods on the basis of his study of both human brain and skull development and human mental development (1974). He subsequently described this as growth spurts during brain development (1978) and identified that the

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physiological growth of the brain also fell into a stage-wise pattern for most humans. These growth periods were seen as occurring at some point within the age 3 to 10 months, 2 to 4 years, 6 to 8 years, 10 to 12+ years and 14 to 16+ years. As a corollary, periods of slower brain growth were seen at some point within the age 4 to 6 years, 8 to 10 years, and 12 to 14 years intervals.

Professor Epstein's concern was to identify the implications of such scientific data for developing educational strategies which might enhance teaching and learning for children and adolescents. He estimated that as many as 85% of children may experience this pattern of physiological brain growth. Epstein posited the relationship between brain and intelligence development in humans might might well explain the developmental learning stages established by Piaget. He further observed (1979a)

> "It can be seen that there is a brain growth stage on the onsets of the Piaget stages whose ages are classically given by Piagetians. Although many investigations challenge the stage linkage of these Piaget stages, recent evidence shows that Piaget stages are more firmly linked to age than supposed even by the Piagetians themselves. It is important to note that the presumptive correlation of brain growth stages and the Piaget stages requires a prediction that a new Piaget stage will be found corresponding to the fifth and last brain growth stage around age 15 years. Beginning in 1975, Arlin has shown appreciable evidence for a fifth Piaget stage, and her most recent data place the onset age as between 14 and 16 years, precisely as predicted.
>
> The nature of the Piaget stages are such that there is a qualitative change in mental functioning at each of the onset stages, as would be expected if there is a very significant increase in neural complexity." (pp. 3-4)

Professor Epstein's data suggest that the brain, like other organs, does grow in a stage-wise fashion. Robert Sylwester's data, (1981, 1982, 1984) further identify ways in which the brain grows during the stages of human development. The respective concerns of professors Elkind and Adelson discussed earlier also support professor Epstein's foregoing statement which was made prior to formulation of their conclusions. Professor Epstein cites Michael Shayer's data on the distribution of learners among the Piagetian learning stages which interfaced with Epstein's developmental brain growth timeframes. Professor Adelson's data (1983) further substantiates Professors Shayer's and Epstein's contentions that most adolescents do not initiate higher formal operational thinking abilities early in that timeframe. Figure 4 presents professor Shayer's data (1976, 1978).

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Figure 4: Distribution of Thinking Abilities
by Piagetian Developmental Stages

Age (Years)	Preoperational	Concrete Onset	Concrete Mature	Formal Onset	Formal Mature
5	85	15			
6	60	35	5		
7	35	55	10		
8	25	55	20		
9	15	55	30		
10	12	52	35	1	
11	6	49	40	5	
12	5	32	51	12	
13	2	34	44	14	6
14	1	32	43	15	9
15	1	14	53	19	13
16	1	15	54	17	13
17	3	19	47	19	12
18	1	15	50	15	19

[Figure 4 taken from Epstein 1979a]

Professor Shayer's data identify average ages at which the percentages of children shown are at particular developmental stage levels. The breakdown indicates whether children are at the onset or maturation of the skills at that particular developmental stage. Patricia Arlin's test (1984a) now allows teachers to identify similar information about each student's learning stage skills in their own classrooms. This will be discussed further in the later section on Cognitive Levels Matching.

Achievement and learning of facts and skills lessens during those segments of the classical Piagetian learning stages which Epstein identifies as lower brain growth or plateau periods. Figure 5 identifies that relationship with the last three Piagetian learning stages.

Figure 5: Brain Spurt and Slow Growth Periods In Piagetian Learning Stages

Piagetian Stage Ageframes	Epstein Growth Spurt Periods	Epstein Slower Growth Periods
Concrete Preoperational 2 - 7 years	2 - 4 years	4 - 6 years
Concrete Operational 7 - 11 years	6 - 8 years	8 - 10 years
Formal Operational 11 - 14 years	10 - 12 years	12 - 14 years
Arlin's Postulated Fifth Piagetian Stage	14 - 16 years	

Figure 5 relates the brain spurt and slow growth intervals posited by professor Epstein with each of the classic Piagetian learning stages. This writer (1981) reviewed the postulation of possible relationships in the growth of the brain to the times at which learning stages appear and signify progressive changes in children's intellectual skills. The possibilities of such correlations of the biological growth of the brain with the Piagetian learning stages are all the more interesting in light of data about children's mental age growth.

Frank Shuttleworth's study (1939) shows that children demonstrate great differences in average mental age growth during particular time intervals in their lives. Professor Epstein (1978) interpreted Dr. Shuttleworth's data in light of the slow growth and spurt intervals shown in Figure 5. During some sequences of these two year intervals, this difference can be as wide as a 40 month increase followed by only 7 months increase in mental age during the next one. Professor Epstein observed this in Dr. Shuttleworth's data on the age 10 - 12 years interval followed by that drop in mental age growth during the subsequent age 12 - 14 years ageframe.

The difference which Professor Epstein projects between the age 10 -12 and the 12 -14 years intervals is interesting in light of similar considerations which Professor Adelson found between older and younger adolescent formal operational abilities as described earlier in this report.

It is important that research be continued into the different ways children can and do learn during the proposed slow and spurt growth periods within the Piagetian learning stages which Professor Epstein identifies. Work underway in the Shoreham Wading River Schools (Brooks, Fusco & Grennon, and

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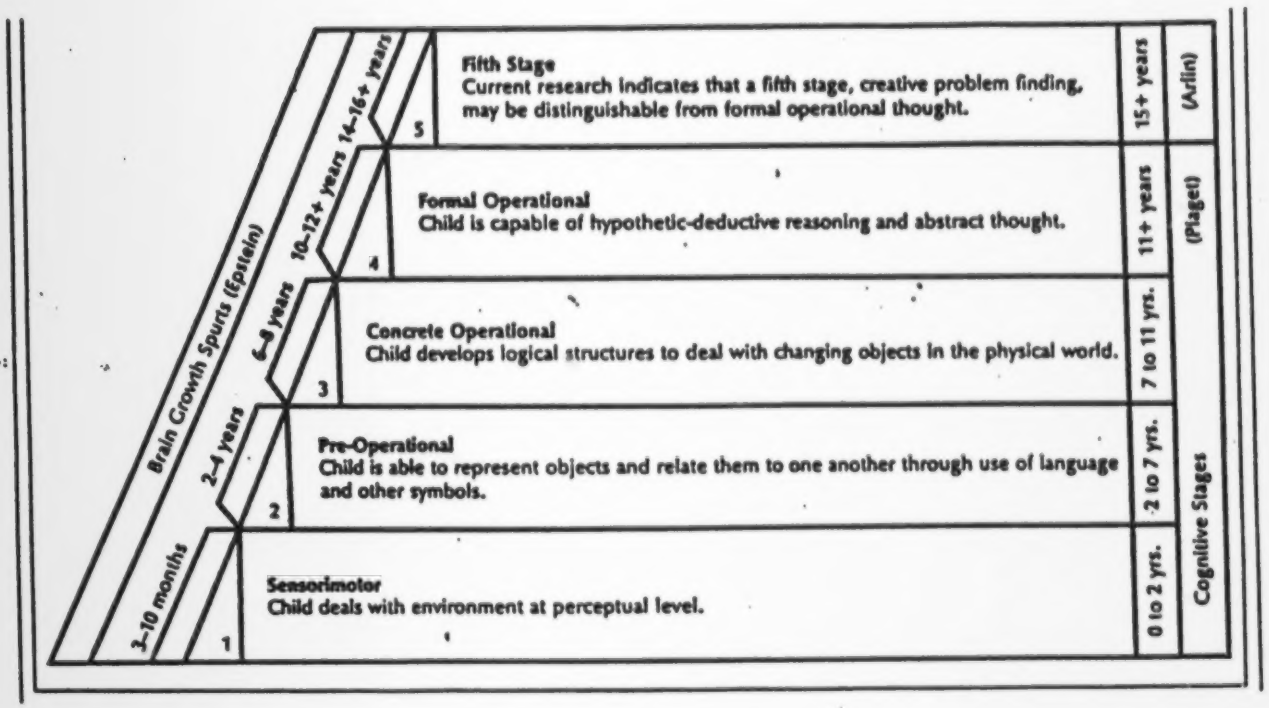
Brooks and Fusco) will be discussed in the following section of this report. Recall the earlier discussion of Adelson's findings regarding differences in how 12 to 14 year-olds develop formal operational thinking skills from 14 to 16 year-olds as you read the information Figure 6 presents on this learning stage.

It is necessary to consider carefully Professor Adelson's findings on the ages at which adolescents demonstrated the ability to initiate and develop mature formal operations during the years of the Piagetian formal operational learning stage. The planning and sequencing of intellectual challenges which young adolescents can be expected to master need to be considered in light of those data. Studies of achievement during the age 10 to 14 age range historically show the following. Achievement during the age 10-12 year interval (which includes most 5th and 6th grade youngsters) is very high. However, it is also clear that increases in school achievement during the subsequent 12 to 14 years age interval (which includes most 7th and 8th grade youngsters) is the lowest experienced by children during any interval in their schooling years. Achievement during the 14 to 16 year (which includes most 9th and 10th grade adolescents) interval increases to about the same level found in the 10 to 12 year period.

These findings enhance the possibility that Professor Epstein may have identified a biological base for the Piagetian learning stages. Research on the nature of the neurological development occurring in the brain during these intervals identified by Professor Epstein shows the brain is developing or shifting and maturing synapses accompanied by significant increases in dendritic growth (Huttenlocher) during these intervals. This development and maturation of synaptic and dendritic growth provides neural networks which allow the child to accommodate progressively more difficult learning and information processing demands. Timothy Teyler and Nicholas Chaia (1984) deal further with this information.

Trudy Fagan and Marion Szymanski are doing longitudinal studies of groups of primary grades children using both brain and intellectual measurements. Their initial findings (1983) further build the possibilities that children do initiate new and higher level thinking skills after, rather than before or independent of, noted increases in the sizes of their brains. As Strahan and this writer identify, educators need to study these implications in examining the existing scope and sequences of learning challenges in school programs. These data further indicate that planning learning experiences

for all children on a constant continuum is an error. The profile of a child's learning achievement across the school years, as was cited earlier, is episodic rather than continuous. Martin Brooks, Esther Fusco, and Jacquelyn Grennon show this relationship in Figure 6.



[From Brooks, Fusco, and Grennon, 1983]

The combination of the Piaget's and Epstein's data provide a powerful reason to consider differences of degree and emphasis which may be expected during particular intervals in a child's school experience. This should not be construed as meaning there are intervals during which learning cannot take place. Rather, these data can assist in identifying how differences in which children acquire new intellectual skills can be used to plan more efficient ways they can deal with facts and information during specific intervals. Educators should study the degree to which children initiate and develop new intellectual skills during brain growth spurt and slow growth periods.

The planning of how a child can best learn new facts and information must be considered in light

of her/his skill development profile at that given time. If, for instance, s/he is in an interval of slow growth and not initiating higher level skills to a great degree, new facts and information might be more effectively assimilated by offering them at levels which use and allow the child to consolidate her/his present intellectual skills. As the child demonstrates readiness to initiate new and higher level skills, the facts and information to be learned can be presented in progressively higher challenges appropriate to the child's increased ability to initiate and develop those skills.

The Epstein rubric is an important means to help define the readiness for a child to move on to higher level processing challenges with maximum success at each level. As one does not drive a high performance automobile in high gear at all times, the child does not think continually at the highest cognitive level s/he has achieved. Children "shift gears" as they demonstrate their increasing ability to use different learned cognitive level skills in different learning settings. As the learner "adds more gears to her/his personal gearbox," s/he will "shift" up and down through those abilities as necessary.

It would be erroneous to assume, for instance, that on the dawn of her/his 10th birthday, every child shifts into 24 months of unbridled brain growth which then comes to a screeching halt on birthday 12 for the next 24 months. In actuality, Professor Epstein's data indicate that the majority of children will experience their individual brain growth spurt or slow growth period somewhere in the two year interval identified. One child might experience a particular spurt during a short and rapid 3 month burst within her/his 10 to 12 years lifeframe. Another might experience the same growth over a more even 20 month period during the same two year interval. The same variance is possible for slow growth episodes. Thus, the Epstein stage intervals are times during which educators can anticipate changes in children's learning skills. However, they should not be considered as universal expectations for the exact times at which each child will experience this phenomenon.

Identification of changes in thinking levels among young children through Piagetian interviews and testing have been available since Piaget's work (Sund, 1977). Development of similar measures for older children and adolescents has been a more recent undertaking. Professor Arlin's test of formal reasoning (1984a) developed upon earlier measures by Paul Ankney and Lyle Joyce, David Burney, and Anton Lawson. The Arlin test identifies whether a child is at low or high concrete operational or

formal operational levels. This information can be used to plan learning experiences which appropriately help learners consolidate present skills and initiate new ones for which they possess readiness.

Cognitive Levels Matching

The development of cognitive levels matching has helped educators to respond to the issues suggested by the interface of the Piagetian and Epstein stages. J. McVicker Hunt (1961) described the major problem facing education as "the problem of the match." Professor Epstein (1981) described cognitive levels matching as the need to provide teachers with the ability: (1) to identify and diagnose student cognitive levels; and, (2) to then organize learning activities which match the learner's readiness to learn information by consolidating existing skills and initiating new ones as her/his readiness indicates. Cognitive levels matching is seen by this writer as dealing with James's concern that "to detect the moment of instinctive of readiness for the subject is then, the first duty of every educator." In providing teachers with these capacities, the ultimate purpose of cognitive levels matching is to minimize both the over and under challenge in learning and identify the most appropriate levels to challenge child and adolescent variance in cognitive abilities during her/his journey through the years of schooling.

The Shoreham-Wading River, New York Schools (Brooks, Fusco, & Grennon, 1983) are now in the fourth year of developing such an approach on a district-wide basis. This program provides teachers with continuing staff development and inservice experiences. Martin Brooks (1984) notes that the cognitive levels matching project sought to facilitate cognitive development by appropriate educational intervention. Teachers involved in the project have gained the skills to identify individual learner's cognitive levels and develop learning activities which match and respond to learner's changing cognitive levels. Along with Professors Epstein, Shayer, and others, Professor Arlin (1984) is working with the Shoreham district in the continuing development of this approach.

Dr. Brooks and Dr. Fusco (1984) describe how the Piagetian principle of constructivism is necessary to develop learning activities which respond to children's differing capabilities as their cognitive levels change. Again, Professor Elkind's (1980) notions on "automatization" and "the

intellectual unconscious" need to be understood by educators in constructing learning activities and an environment which does not incorrectly assume that youngsters think as adults do. Drs. Brooks and Fusco provide specific examples of how the child's point of view must be central in professional decisions regarding curricular adaptations, questioning techniques, testing, and administration of school programs. Dr. Brooks (1984) discusses the importance of the relationship between the "knower and the known" in cognitive levels matching. Charles Smock (1984) described this as the "subject-object unity." Dr. Brooks (1984) further observes that

> "the notion that knowledge can be acquired via incremental skill or subskill acquisition, the sequence of which is pre-identified and imposed though adult logic applied to children's constructions, ignores the primacy of the child's point of view. Yet it remains a preeminent foundation of our educational system." (p.24)

By using the constructivist principle in cognitive levels matching, teachers learn how to format learning so that children can construct the means for their own learning. Irving Sigel (1984) maintains that all humans understand the world through representations of it. Constructivism can use "distancing strategies" as a means to allow the learner to construct this relationship from her/his own experience of the world in relationship to what is to be learned. Professors Sigel and Cocking (1977) make the important point that distancing is not detachment of adults/teachers from the child, but facilitating and working with the child as s/he constructs an understanding of that situation. Cognitive levels matching substantiates that children can neither accelerate content acquisition nor accelerate incremental sub-skill development beyond their cognitive skill levels at a particular developmental stage. Constructivism helps the child to construct ways to process information rather than "parrot" content which is beyond her/his ability to understand. For example, it does a does not benefit a child to impose formal learning expectations prematurely when that child can learn facts and information effectively in a different way by using lower level skills which are already in place.

In writing of her experiences in designing and teaching cognitive levels matching activities, Jacquelyn Grennon (19840 observes, "the delicate factor in bringing students to the leading edge of their intellectual abilities lies in the teacher's understanding of the inextricable tie between affect and cognition" and further, that "Teachers need to attend not only to the cognitive development of students, but to the vulnerable emotional states that various teaching practices can generate." (p.15)

While longitudinal evaluation of the cognitive levels matching project at Shoreham-Wading River is still in process, Dr. Brooks (1984) reports three findings from preliminary data.

> "1. The CLM experience has significantly touched most participants: 'I never realized that my questions were so closed;' 'I finally understand why my students never understand this concept;' 'The problem I presented to the class was not the same problem most of the children perceived.'
> 2. It gives teachers a common focus for communicating about children: 'Missing addends is a tough concept for John because he is unable to conserve numbers.'
> 3. It gives teachers a way to assess the appropriateness of curriculum materials: 'The metaphors in this book may be too complex for my class.'" (p. 27)

Even from this preliminary data, cognitive levels matching has demonstrated a capacity to increase teacher understanding the dynamic interaction of teaching and learning within a constructivist framework. It would appear that cognitive levels matching does provide an effective strategy for planning instruction to deal with the match of readiness and task which both James and Hunt observed to be the major challenge facing educators.

Brain Growth Periodization-Cognitive Levels Matching Issues

The development of middle level school experiences which respond to the ways in which transescents can think and process information raises important issues for responsive curriculum planning. This writer sees that these also pose questions for the areas of brain growth periodization and cognitive levels matching presented in the previous two sections. Figure 7 adapts information from Professor Arlin's chart (1984) and presents the interface of data on brain growth stages with both cognitive levels and the Piagetian learning stages.

Figure 7: Relation of Brain Growth, Cognitive and Piagetian Data

Brain Growth Stage	Cognitive Levels	Piaget Stages
3 - 10 months Neuron Development Cerebellum		1. Sensorimotor Motor (0-18 months)
2 - 4 years angular gyrus Hearing/binocular vision language development	IA - Play IB - Trial/Error	2. Preoperational (2-(5-7) years

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Brain Growth Stage	Cognitive Levels	Piaget Stages
6 - 8 years angular gyrus reading/writing	IIA - Some attempt at system	3. Concrete Operations (5-7) - (11-14) or (15-17) or ?
10 - 12 years rear right hemisphere abstract thought	IIIA - Systematic, generalizes but doesn't exhaust	4. Formal Operations (11-14 years or ?)
14 -16 years angular gyrus (?) (15-17) rear left hemisphere problem finding and self-awareness	IIIB - Fully formal, considers rival hypotheses, etc.	5. Post Formal(Arlin)

[Arlin's sources in developing the information in Figure 8 were Epstein (1978), Sylwester (1982), and Elkind (1969)]

Learning issues about transescent youngsters deal with aspects of both concrete and formal operational learning stages coincide during the middle school years. Likewise, Professor Arlin's (1975) positing of a possible fifth Piagetian growth stage requires continuing study. Her research is building evidence as to the possibilities of a fifth Piagetian stage which corresponds to the brain growth stage professor Epstein identifies during the age 14 to 16 years interval. This area has importance for middle level education because a number of students will precociously achieve intellectual skills during their middle level school years normally developed by most in their high school years. To respond appropriately to the learning needs of these precocious youngsters, middle level educators must become knowledgeable about the continuum of formal learning abilities

Research Issues in Brain Growth Periodization

The Validity of the Epstein Findings

Professor Epstein's notion and supporting data base that both brain and mind do not grow on a constant continuum through the years of schooling stand as compelling reasons to attempt to identify ways of improving educational responsiveness to human learning abilities. Subsequent findings and the exact interpretations and implications of present and future data will undoubtedly grow, develop and change. This writer's investigations (1981) suggest that these data do offer important insights into how

transescents do and do not progress in their abilities to deal with and process information. However, it has not been suggested that the Epstein data would eternally hold true.

Barbara Hutson (1984, 1985) cites studies which she sees as disagreeing with Epstein's findings (Hahn, Walters, Lavooy and Deluca, 1983, McCall, Meyers, Hartman and Roche, 1983). A case can be made for how their findings differ from those of professor Epstein. Professor Hutson contends these studies provide a basis for "disproving" Epstein's findings. These studies do not monitor and measure growth and progress of learners longitudinally any more than did professor Epstein's studies. While these studies dispute professor Epstein's findings, they do not disprove them. They do, however, raise important issues which can be only determined from longitudinal data about how students do learn.

Professor Hutson (1985) also states that one of her concerns arose from Richard McQueen's contention that in his examination, professor Epstein's findings "did not add up." This notion has been misconstrued by many and requires clarification. Data can be statistically presented in particular ways which can add emphasis to aspects of those data. One will invariably select the statistical presentation which best highlights the findings in her/his data. In displaying his data in a favorable fashion, Professor Epstein was not guilty of "incorrect" treatment of his data. However, those not familiar with his data may come to such a conclusion when it is criticized as "not adding up." Yet, while errors will occur, they do not necessarily mean that an entire work is invalid. In that respect, one of Mr. McQueen's criticisms (1984) of professor Epstein's data was based upon Stephen Gould's (1981) comment about an inaccuracy he surmised in Epstein's data. In responding to Richard McQueen, professor Epstein (1984) pointed out the errors in professor Gould's inferences about Epstein's data. However, that error did not discredit the importance and quality of professor Gould's entire work in itself.

Professor Hutson (1984) further criticizes a statement this writer made in 1980. She comments that "Toepfer cited researcher Michael Shayer's work on cognitive development as support for Epstein's notion that supports in cognitive development are correlated with spurts in brain growth. Yet here too, inconsistencies appear: Toepfer stated that only 12 percent of 12-year-olds had reached formal operations, yet Shayer's 1982 report shows almost 40 percent of 12-year-olds have either achieved beginning or mature formal operations." (p. 35)

The reader is asked to note that professor Hutson used 1982 data to criticize, as inconsistent,

this writer's use of 1976 and 1978 data in a his making a 1980 statement. This writer's statement used professor Shayer's data (1976, 1978) showing that only 12 percent of 12-year-olds did reach formal operations. However, professor Shayer's 1982 data do not totally contradict this writer's 1980 statement. Actually, the measures of formality and the populations he used in gathering his data reported in 1982 differed from those which he used in gathering his 1976 and 1978 data.

Validation of both professor Epstein's data and the rubric his work suggests for educators must be carefully approached. Quantitative and qualitative data bases to make those decisions do not yet exist. The thesis which professor Epstein, this writer, and other proponents have attempted to develop are being dismissed by some before the necessary base of data to make such judgments is gathered. The validation or rejection of the Epstein rubric and his data must consider two concerns. First, as professor Epstein (1984) wrote in his response to Richard McQueen's critique of his work, it remains for neurologists rather than educators to determine the quantitative and qualitative validity of his work in that field. However, most criticism about the validity of professor' Epstein's work is being promulgated by educators and not by neuroscientists. Second, the validation of the Epstein rubric will require a base of data from experimental and other school practices (e.g. cognitive levels matching and other approaches) which are based on the application of the Epstein rubric to teaching-learning situations.

It would appear that educators who initially accepted the idea behind Epstein's work apparently did so without reading and studying data. The willingness of many of those educators who initially supported the notions in the Epstein rubric to summarily reject them may indicate they still have not yet examined that data.

It is also true that the design, application and study of experimental educational approaches which apply aspects of the Epstein rubric have, as yet, not been adequately developed. For these reasons, this writer maintains that current efforts suggesting both quantitative and qualitative rejection of professor Epstein's work are both premature and unduly pejorative. Discouraging attempts to utilize that rubric for identifying how schooling might test the Epstein rubric is contrary to objective scholarship. The current acceptance/rejection controversy over professor Epstein's work has been largely based on different ways which educators have suggested for arranging and treating professor

Epstein's data. Massaging data can suggest ways to further examine data but, in itself, does not necessarily confirm or reject those data.

It seems clear that definitive qualitative and quantitative neurological and educational validation of the Epstein data and rubric will require further time and development. To reject professor Epstein's work prematurely, on the limited bases of data available at this time, could preclude the subsequent development of significant advances which could conceivably evolve from careful, unbiased study of his work. Thorough, effective research and development requires suspension of the kinds of judgments which are part of the current controversy and opinion about the Epstein rubric. This writer is of the opinion that efforts to come to closure on professor Epstein's work at this point in time may well prove more biased than conclusive.

Over-Challenging/Under-Challenging

Professor Hutson comments (1984, p.36) that there are dangers in professor Epstein's and this writer's concern to protect "children from intellectual stimulation." That inference is incorrect. Professor Strahan (1985) observes that professor Epstein and this writer's concern is to make learning challenges more appropriate to learner readiness. Professor Epstein and this writer have suggested that neurological findings could provide a basis for educators to develop means to measure changes in learners' cognitive abilities during their school years. Cognitive levels testing makes it possible to gather these data in local middle level school settings. Based upon these test findings, educators can attempt to match learning activities with those changing levels and avoid the problems of gross over- or under-challenging a child's readiness and ability to learn. It is critical that educators identify the limits at which precocious learning challenges reach a point of no return. There is no reason to surmise that teachers can substantially cause children to initiate new and higher thinking skills by teaching them information which is beyond the existing cognitive levels they have achieved.

On the issue of over- and under-challenge, both Richard McQueen (p. 68) and Professor Hutson (1985, p. 36) take issue with professor Epstein and this writer on the degree to which learners can initiate new and higher level learning skills during the times Epstein has identified as low brain growth periods. This writer maintains that it is an error to assume that children can consistently initiate

and develop newer and higher level thinking skills across their years in schools. Consolidation and maturation of newly initiated thinking skills is an important issue in this respect. The issue is not whether or not students can or cannot initiate novel and higher level cognitive skills during such a period, but the degree to which it can be demonstrated that individual students actually do this at particular points in their schooling years

There are points in the learner's intellectual development when this requires careful attention so that the learner fully consolidates those newly developed skills as a basis for her/his subsequent initiation of new and higher level ones. This does not mean that attention should not be given to initiating higher level skills as that learner demonstrates her/his readiness to do so. As previously mentioned, professor Arlin's (1984a) test assists identifying that readiness. However, schools traditionally have paid much more attention to moving learners ahead "en masse" to new skills than to identifying and dealing with the consolidation issue on a differentiated basis. In practice, schools typically establish norms which become expectations and a schedule by which most students are supposed to initiate new skills. Before dismissing this idea, think of the kinds of skills which the standardized tests (Iowa Test of Basic Skills, etc.) administered in the middle level schools of our nation actually measure. Do we not indicate to parents that their child is deficient if s/he does not meet the norms of skill development measured by these tests? However, we seldom explain that these tests may actually have identified a youngster's lack of readiness and discuss her/his need to consolidate existing skills before s/he can initiate and develop the skills which are the norm on such tests.

Youngsters lacking such readiness are quite often considered as deficient and in need of remediation. Yet, how a learner can be remediated for something for which s/he is not yet developmentally ready? Schools often further compound this problem by matching expectations for teaching and learning subject matter and information with a constant continuum of advancing cognitive skills. This means learners who are neither ready nor able to maintain this continuum of progress toward higher level cognitive skill mastery are doubly penalized. If they are not ready and cannot learn the level of skills expected, they also cannot fully understand new content when it is presented at cognitive levels above their comprehension. Professor Epstein and this writer do suggest that schools devote more time to identify learner readiness to deal successfully with new and higher

intellectual challenges. As the learner demonstrates that readiness, s/he can be properly challenged to develop the appropriate skills and learn new content as a means to initiate and develop those skills. However, if the student is not ready a for particular skill, it is suggested that the challenge to initiate that skill will be ineffective and largely frustrate that student.

This writer's work on the "Turn-Off Syndrome" (1980) indicates a major problem for some transescents in moving from their middle level to high school experience. These data recommend providing learning activities which assist transescents consolidate existing skills. This can then facilitate their initiating novel cognitive skills as that readiness can be confirmed. Depending on the profile of learners' abilities, varying emphases on consolidation and the introduction of appropriate, new skills can be provided in learning activities offered at appropriate times. The new information to be learned can then become vehicles for initiating those skills for which students demonstrated readiness. This can effectively help to initiate and develop appropriate cognitive skills and facilitate better learning of information than those traditional approaches which assume that most students can continuously develop higher level skills throughout their school experience. This attempt to find the most appropriate levels for challenging learners does not warrant the criticism that it "under-challenges" them.

In other words, teaching at any time must be concerned with the degree to which the learner has consolidated skills taught previously before launching ahead into newer ones. Successful initiation of new skills will, in varying degrees, depend upon one's full understanding or mastery of those skills which the learner has recently put in place. Specifically, if an individual student is at a particular point where s/he lacks the readiness to initiate and develop particular higher level cognitive skills, professor Epstein and this writer maintain that forcing the student to learn such skills can prove ineffective in three ways.

First, if a particular skill is not largely learnable at the time it is taught, frustration and failure seem more than likely to occur at those times. Second, we should anticipate that one's learning of particular content and subject matter may be confounded by imposing cognitive skills which are at inappropriately high levels for an individual at that particular time. Third, the child's self-esteem as learner can be lowered by the results of her/his difficulty and/or inability to learn both

the skill and the content in such situations. The importance of David Elkind's statement (1980) as educators consider the over- and under-challenging issue persists.

"Challenge is indeed useful, but we need to distinguish between intelligent and unintelligent challenge. If the challenge is too difficult, so that no amount of struggle produces success, then the result is failure and frustration. Intelligent challenge in education provides a reasonable match between the logical substructures of the task and the current cognitive development level of the student." (p. 25)

It is submitted that appropriate use of cognitive levels matching activities can facilitate one's learning of new facts and information to mature those cognitive skills which have been developed and presently are in place. Upon this basis, individuals can then initiate, learn, and master new and higher level cognitive skills as they demonstrate their "current cognitive development level" matches the "logical substructures of the learning task at hand."

Application Concerns

Middle level educators, schools, and organizations have been highly interested in hearing and considering the Epstein data and this writer's suggestions about possible application of those data. This writer feels the interest of school districts in examining particular aspects of these data rather than making premature moves to develop programs upon professor Epstein's findings is commendable. Professor Hutson, however, has expressed concern (1984, p. 34, 1985, p.8) about the eagerness of middle level educators to accept the Epstein findings. Yet, at the present time, this writer knows of no districts which have developed "brain-based" curricula and programs based upon these findings.

This writer advocated (1984, p.36) that "it becomes imperative that educators resist the temptation to implement tentative programs until an adequate basis of study by curriculum planners and neuroscientists in those respective ideas has been undertaken." However, professor Hutson refers (1984, p. 36, 1985, p. 9) to the "Epstein and Toepfer model." There is no such model. The implications which professor Epstein and this writer see that neurological findings suggest for education can hardly be considered a model. To the contrary, professor Strahan (1985) points out that the Epstein data suggest no "brain-based" curriculum but do urge that school programs develop educational

challenges which are responsive to and compatible with the readiness levels of learners.

The Cognitive Levels Matching project at Shoreham, NY has identified the problems which learners experience in attempting to accelerate content acquisition and the development of incremental sub-skills beyond their achieved Piagetian thinking stages. Professor Arlin's test (1984a) can identify whether a youngster is a either a low or high concrete or formal operational thinker at that point in her/his school years. Therefore, middle level schools now can gather this kind of data about their own students. Such data could then be used in planning and developing approaches which respond more appropriately students' changing skill profiles. As middle level schools design and refine these efforts, data on the successes of these approaches can be gathered and studied. Decisions about the validity of what the Epstein rubric suggests can then be considered in light of such information.

In her 1984 article, Professor Hutson indicates that the cognitive matching project which developed at Shoreham-Wading River has a "troubled prognosis." (p. 36) Her comments omitted references to the several sections of the previously published book A CHILD'S BRAIN (1984) which discuss in detail the particular accomplishments of that project. Hutson's article leaves the reader with the erroneous impression that the Shoreham project is in difficulty. However, articles by Brooks, Grennon, and Sigel (1984) which appeared a month after Professor Hutson's statement (1984) identify the growing success of that project. As David Strahan (1985) points out in his response to Professor Hutson's 1985 article, the Epstein data suggest no "brain-based" curriculum but only to make educational challenges responsive to and compatible with the level of readiness of learners. Yet, Professor Hutson continues to allude to the shortcomings of the brain-based curriculum supposedly developed by Epstein and Toepfer.

Professor Hutson also comments (1984, p.35) "Because Epstein's 1974 review has not been replicated or further analyzed, Toepfer's apparently inconsistent statements must both be based on the same data." In reverse order, the answers to these concerns are, inconsistent, no, the same data, yes. This writer has reported (1980, 1982) the interface of the ages at which many transescents come to a stop in their achievement with the transescent age interval which professor Epstein identifies as slower brain growth period. It was found that these episodes occur at differing times within the 24 month intervals which professor Epstein identifies as slower brain growth intervals.

Some individual youngsters appear to have longer while others have shorter periods during which they best initiate novel cognitive skills. During her/his age 10 - 12 years interval, an individual student may experience her/his personal profile of growth rapidly in a particular 3 or 4 month period. Another student may experience her/his growth more gradually during an 18 month period within that same age 10 -12 years interval.

Professor Hutson's "impatience" with the ratio of proclamations to proof for brain-based curriculums" (1984, p. 36) overlooks the successes reported in the Shoreham-Wading River project mentioned earlier and the work of Trudy Fagan and Marian Szymanski (1983) with primary grades learners. These experiences have attempted to develop more effective matching of teaching to learning readiness and were never proclaimed to be "brain-based curricula. Professor Strahan notes (1985) that learning experiences may become more brain-compatible in the sense of more approximately matching and challenging student abilities and readiness to learn at particular cognitive levels. He observes:

> "What she (professor Hutson) does not report is that Epstein and Toepfer present brain growth periodization as a theory and repeatedly urge the 'testing of this supposition. (p. 658)' Their suggestion is that 'if this supposition is validated through testing, education in the middle grades must then develop a readiness in most students for later development of new cognitive skills (p.658).' Their recommendations then include the discontinuation of MASS introduction of novel cognitive skills, presenting new information at existing skill levels, and working to mature existing skills." (p.13)

The current efforts we are witnessing to improve "excellence" in schools must realize that the neuropsychological concerns discussed here suggest one essential truth. That is, there are limits as to how early we can expect children to be able to do certain kinds of intellectual processing. It is not a matter of trying "harder and earlier" in getting children to master subject matter and cognitive skills. This writer is convinced that the matching of the learner's readiness, cognitive level, and the difficulty of the learning challenge remains the central issue in all this.

It is critical that we respect the reality which research in the areas mentioned here is trying to identify as the limits at which precocious learning challenges reach a point of no return. Expecting that teachers can cause children to initiate new and higher thinking skills by teaching them information which is beyond their cognitive levels in their growth and development will place education in a "no-win" situation. It may well be that many of the changes in educational law being mandated to schools by state legislatures already are violating that reality. Therefore, it is imperative that continued

study of the areas discussed here and their implications for developing appropriately responsive school programs be given our full attention. Nothing positive is to be gained by prematurely dismissing this issue because there has not yet been time to develop the longitudinal data base needed to assess fully those possibilities at this point.

It has been difficult to establish opportunities to work with aspects of professor Epstein's data. Coming to conclusions about the Epstein rubric without further opportunities to examine projects based upon it does not seem appropriate. However, one should not overlook the successes reported in the Shoreham-Wading River project and the work of Trudy Fagan and Marian Szymanski (1983). These experiences have attempted to develop more effective matching of teaching to learning readiness. It is not accurate, as some have misinterpreted, that these attempts were proclaimed to be "brain-based curricula."

Future Research - The Need for Longitudinal Study

As previously mentioned, William James's (1890) concern "to identify the moment of instinctive readiness for the subject is, then, the first duty of every educator" remains a persisting issue in researching this area. Transescent learning issues deal with aspects of both concrete and formal operational learning stages during the middle school years. Longitudinal research is needed to answer the following questions.

1) Can precocity and earlier readiness for elementary logical operations and cognitive operations common to later learning stages be facilitated?

2) Can precocity and earlier readiness for the skills of the formal operations learning stage be facilitated?

3) Can learning behaviors in which concrete preoperational children deal with mastering and consolidating sensorimotor tasks be identified?

4) Can learning behaviors appropriate with concrete preoperational cognitive levels be identified and enhanced?

5) What kinds of activities could be developed and/or utilized to ascertain these possibilities?

The concrete operational learning stage brings the maturing of concrete operational processing skills as well as transition to initiation of beginning formal operational skills by a few precocious children. Middle level education needs to identify effective and appropriate ways to mature concrete operational learning abilities. This is important because readiness issues become increasingly more complex for the transescent group. The definition of appropriate middle level learning issues must also deal with the social-emotional aspects of beginning pubescent tasks which appear during this developmental stage. The use of learning activities appropriate to cognitive levels of individual children during their concrete operational developmental stage could become very helpful as means to deal with their pubescent transition problems. Middle level educational researchers need to deal with and help children resolve the following issues during their concrete operational developmental stage.

1) Can precocity and earlier readiness for hypothetical deductive reasoning skills associated with the formal operations learning stage be facilitated?

2) What problems for learners may be expected in efforts to do this?

3) What issues of early onset of pubescent development pose the greatest difficulties in dealing with concrete operational development?

4) Can learning behaviors which assist middle level learners deal with mastering and consolidating concrete tasks be identified?

5) Can learning behaviors for dealing with individual and small group concerns about pubescent development issues be utilized to clarify concrete operational learning needs?

6) What kinds of activities could be developed and/or utilized to ascertain these possibilities?

Research about the formal operational stage abilities of middle level learners needs to identify the degree to which intervention strategies can either develop or further mature those skills or tendencies during this stage. The transescent's personal-social development during her/his formal operational developmental stage could provide the most meaningful set for initiating and refining her/his learning skills. This could contribute both to developing and refining of one's thinking skills for

present use as well as in later adolescent and adult life. Middle level education needs to seek answers to the following questions about formal level thinking skills as they appear in middle level learners.

1) Which pubescent development issues pose the greatest difficulties in dealing with the development of thinking skills during the middle level school years?

2) Can learning behaviors which assist middle level school learners learners deal with mastering and consolidating formal operational tasks be identified?

3) Can learning behaviors for dealing with individual and small group concerns about pubescent development issues be utilized to clarify formal operational learning needs?

4) What kinds of activities could be developed and/or utilized to ascertain these possibilities?

Professor Arlin's (1975) positing of a possible fifth Piagetian growth stage requires continuing study. Her research is building evidence that there is a possible fifth Piagetian-type developmental stage which corresponds to the brain growth stage which Professor Epstein identifies during the age 14 to 16 years interval. This area has importance for middle level education because a number of transescents with precocious abilities do achieve intellectual skills during their middle level school years which are not normally developed by most youngsters until their high school years. To respond appropriately to the learning needs of these precocious youngsters, middle level educators must become knowledgeable about the continuum of formal learning abilities.

Readiness Issues Relating to Hemispheric Specialization of the Brain

There is need to study ways in which Electroencephalograms (EEG) can corroborate information on brain hemisphericity or lateralization from the Torrance Style of Learning and Thinking (SOLAT) tests (1977, 1978, 1980, Reynolds, 1979). Furst has examined implications of what EEG patterns suggest about right hemispheric visual-spatial functions. Galin, Johnstone, Nakell, and Herron (1979) further identify information about how normal children develop the capacity to transfer tactile information

between hemispheres. Middle level education could benefit from research data on pedagogic concerns about hemisphericity with the growing body of EEG and other data on patterns of brain function.

The left hemisphere contains the major language and speech processing centers in the brain. However, the right hemisphere also contains minor centers for language and speech processing (Glassner, 1980, Searleman, 1977). Cultural differences between occidentals and orientals reflect the latter's advantage in right hemisphere language and speech processing (Merrill, 1981). Oriental cultures concentrate on facilitating young children's development of right hemispheric readiness to support language skill development. Children are assisted in gaining a "picture/image vocabulary" before turning to typical left hemisphere linear processing skills which dealing grammar, word patterns, syntax, and the like. Occidental cultures, on the other hand, move youngsters to linear language skills as soon as reading readiness (a left hemisphere linear function in our culture) is established. Occidentals appear never to catch up with orientals in these right hemisphere capabilities. We need to examine whether earlier development of right hemisphere and lateralized language processing skills could alter this skill development pattern among middle level students in our culture.

Left hemisphere skills dominate in our culture to the point that school experiences and curricula are also strongly biased toward linear processing skills. The issue could rest in the fact that this "left hemisphere curriculum" is also taught by adults who largely are left brain dominant themselves. One means to research and determine alternate approaches would require that pre-school, kindergarten, and first grade learners be taught by two person teaching teams. For experimental purposes, one of the two teachers on each team should be right brain dominant. This would establish a favorable placement for youngsters who come to school as either right brain preferred or dominant learning styles. Every child would then have a teacher who could match her/his dominance as well as a model to nurture subordinate skills residing in their subordinate hemisphere. While not a middle level educational concern, development of such opportunities for younger children could facilitate more effective learning during later years in their school experience.

Research with such a model could further identify information about the actual cognitive limits and capacities of young children to respond to early learning of skills attributed to each hemisphere. This would also place them in a setting which provides daily access to teachers who can respond

specifically to both their dominant and subordinate skills and processing centers. This could identify possibilities for lateralizing skills in each hemisphere and bilateralizing abilities in both hemispheres which could help children learn to process information in both linear and visual spatial ways. Cohen and Gainer (1976) and Edwards (1979) both consider how visual spatial learning approaches normally associated with art and drawing might be be learned by more persons than is possible in today's predominantly linear organization of the majority of cognitive processing skills in our culture.

Neural Plasticity

The situation just considered raises the issue of the degree to which children have ability to process information with centers which reside in different areas of the brain. This deals with the neurological phenomenon known as neural plasticity. Levine (1984)presents the issues of neural plasticity which are central to the child's ability to redirect hemispheric and other neurological skills. Complementary specialization of the brain is possible only as this plasticity or, the ability to re-direct development of neural networks exists. Changes in an individual's handedness, dominance of eye and the like, can best be reorganized during the neural plasticity period. As the brain matures, the myelinization process gradually ends one's neural plasticity (Johnson, 1980.) When a neural circuit matures, it is encased in a sheath of fatty myelin. While this intensifies the strength and the speed of that circuit to transmit its neural function, it also restricts and largely limits the circuit's ability to redirect its functions. As Gazzaniga comments, cerebral dominance as a decision system is largely determined by the development of neurological networking before myelinization is complete.

Myelinization of the corpus callosum is a critical episode. The corpus callosum (Sperry, 1964) is the massive fiber system connecting the two hemispheres and though which the adult brain must interact. His continuing investigation of the corpus callosum's interface of hemispheric functions (1982) eventually resulted in his selection as a Nobel Laureate. Lenneberg (1967), Yakovlev and Lecours (1967), and Levine (1984) each identify that the full myelinization and maturation of the corpus callosum is not complete until somewhere during the age 10 to 13 year interval. The fact that this process occurs for most persons during their middle level school years requires that middle level

educators give careful consideration to the information summarized in the remainder of this article.

Initiation of the processing skills residing in each hemisphere prior to completion of the corpus callosum's myelinization are critical events in this episode. There is reason to believe that if these abilities of each hemisphere are not initiated prior to completion of the myelinization of the corpus callosum that further development of these abilities is severely curtailed. Case histories show that many persons suffering a severe cerebral stroke in their left hemisphere (site of the major language processing centers) do not regain speech or language facility. However, a minority of such victims with this specific trauma do regain speech and language facility. Since neural tissue is so fragile that it normally infarcts after such trauma, it is felt that those individuals who do regain speech and language facility actually did not rehabilitate their left hemisphere. Patricia Neal, the actress, was such a case. It is contended that such individuals had developed enough of the minor speech and language processing systems in the right hemisphere of the brain prior to complete myelinization of their corpus callosum. This is given as the reason they could process though the corpus callosum and relearn speech and language facility by using these minor centers following the stroke in their left hemisphere. It is further assumed that the majority of victims of left hemisphere stokes who fail to regain speech and language facility had experienced insufficient development of their right hemisphere minor speech and languages centers prior to complete myelinization of their corpus callosum. Thus they could not process through the corpus callosum to initiate speech and language facility in the minor processing centers in the right hemisphere following the stroke in the left hemisphere of their brain. There is a need to examine the degree to which known bilateralized thinkers do and do not experience this phenomenon following massive cerebral stokes in the left hemisphere of their brains.

In the matter of dominance in handedness, the following has also been observed. Cross dominance means that one side of the body is controlled by the opposite hemisphere of the brain. If a person's right arm is dominant, s/he is almost always a left brain dominant individual. Children who break their dominant arm prior to myelinization of their corpus callosum prior to age 14 usually demonstrate the ability to develop particular skills in their subordinate arm while incapacitated. This includes skills such as writing, throwing a ball and applying make-up or grooming. This adaptability is a prime example of neural plasticity. Before neural circuits have fully matured and myelinized, a

trauma, such as a broken dominant arm, can stimulate still immature circuits to redirect their functions. Such episodes may facilitate increases in cross and mixed dominance as well as increase bilateralization of functions in both hemispheres. This happens far less frequently to adults who experience similar accidents. Limited data suggest that those few adults who can make such adjustments after an injury, such as a broken dominant arm, have achieved varying degrees of bilateralized capabilities in their brain prior to myelinization of the corpus callosum.

In a real sense, the middle level school years mark the end of the period of neural plasticity in human growth and development. Middle level schools deal with the final years in the youngster's lives when initiation of skills utilizing the processing centers in each hemisphere can be undertaken. Thus middle level school programs must give attention to providing learning activities which initiate development of the learning centers in each hemisphere before the myelinization of the corpus callosum is completed. Failure to do so will limit most learners from developing centers in their subordinate hemisphere in their later years.

Recent Data on Sex Differences and Hemisphericity.

Wittelson (1976) discusses several areas of sex difference which impact on learning and expectations of typical school programs. The corpus callosum in females is 40% thicker than in males. Consequently, females have considerably more interconnecting possibilities between hemispheres. Males usually have larger right hemispheres while the reverse is true of most females. Michalak (1984) has made some fascinating observations on these differences. Because of cross dominance, the right hemisphere has dominant input from the left ear while the left hemisphere responds more directly to the right ear. This establishes some interesting advantages and disadvantages for females and males.

The left hemisphere contains the major language centers. Females typically have a larger left hemisphere and tend to be stronger processors of language. This gives females an added advantage because normally they have direct input of language from the right ear directly to the left hemisphere where the dominant language processing centers reside. This is offered as a biological reason why females typically respond to language better than males. This means they directly input from their dominant right ear to the major language processing centers in the left hemisphere without having to

cross over through the corpus callosum. They dominantly focus on language sounds and tend to be distracted by environmental sounds processed by their subordinate left ear to the right hemisphere.

Males, on the other hand, have larger right hemispheres and their left ear sends environmental sounds directly to their right hemisphere which deals primarily with holistic visual-spatial inputs. Contrary to females, they dominantly focus on environmental sounds and often tend to be distracted by language sounds processed by their subordinate right ear to their left hemisphere. As their left dominant ear attempts to support the right in dealing with language inputs, males experience a disadvantage from females. Their left ear transmits language to the right hemisphere where it then must process that input through the corpus callosum to reach the major speech centers in that left hemisphere. With a 40% thinner corpus callosum and less interconnecting fibers in that fiber system, males experience an approximate 20 to 40 millisecond delay over females in transmitting language/speech signals to the language processing centers in their left hemisphere. Michalak's investigations indicate that cognitive development of males and females is strongly influenced sex related variables such as these auditory input differences. This supports Kinsbourne and Hiscock's earlier positions (1978) on the influences of cerebral lateralization on cognitive development. Females are more lateralized in the left and males in the right hemispheres. This also reinforces Riegle's (1977, 1979) findings about differences in lateralized brain development of adolescent females from males.

Brain Hemisphericity Middle Level Education Concerns

Despite the growing data supporting hemispheric specialization, it is important to consider Levy's contentions (1982) that children do think with whole brains. Hemisphericity research should help us identify both the holistic and hemispheric ways in which transescents can integrate their hemispheric abilities during their middle level years. Careful investigation of the relationship of learning during the middle level years to the bilateralized abilities of individuals needs to pursue two major questions.

1) To what degree does learning during the age 10 to 14 years period relate to the way that transescents

can deal with a particular learning situation from both linear-sequential and visual-spatial points of view?

2) Does a major criterion for learning actually lie in one'e ability to examine or dissect a situation in a linear, deductive sense and then re-assemble it in an inductive, holistic manner? A sub-investigation of this second question should also pursue the degree which individual learners demonstrate an ability to dissect a situation in a holistic manner and then re-assemble it in a linear manner?

As information relating to these questions is gathered, the importance of helping all children optimally develop the processing centers in each hemisphere of the brain may gain higher priority. Likewise, learning activities may also give increased priority to helping learners solve learning tasks by using skills and capabilities which integrate their hemispheric abilities as they progress though their middle level school years. The growing data base regarding neural plasticity and myelinization of neural circuitry generally, and of the corpus callosum in particular, needs particular study in light of data from both holistic and hemispheric investigations of how children do learn and think.

Conclusion

Raising critical concerns about brain growth periodization is important in refining its state-of-the-art. However, contrary opinions about this area of information not be generalized or misconstrued as conclusions or, in themselves, bases for accepting or rejecting professor Epstein's work or the Epstein rubric. This writer believes that the necessary data bases required to make such decisions have not been fully developed. This needs to be done both in neurological areas and in work based upon experimental application of various aspects of the brain growth periodization data in educational settings. For this reason, the time to accept or reject this area of information does not yet appear to be at hand. As discussed earlier, designing efforts to gather data which answer the questions and deal with the research issues raised here will require longitudinal study. These activities are foundational to efforts which properly seek to validate Professor Epstein's work. Keeping an open mind on the Epstein rubric until such data is gathered, analyzed, and considered is an

essential concern for educators interested in the issues raised by professor Epstein's work.

The areas of hemispheric specialization of the brain and neural plasticity offer additional reasons to consider how middle grades educational experiences need to respond to the growing base of data in neuropsychology. Neuropsychology certainly offers no panaceas to learning needs in middle level education. However, we need to assess our goals and expectations for how learning takes place during transescence in light of these areas of information. In addition, particular school practices should be considered in terms of the way they deal with the reality of the issues discussed here.

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